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**(54) Process for the production of a composite friction bearing material**

(57) A process for producing a bearing material from a powdered or granular mixture of polytetrafluoroethylene, lead and synthetic resin applied to a treated metallic substrate with a porous adhesive layer and using alternating pressures and temperatures so that there is obtained a coating at least 0.2 mm thick. a) on the adhesive layer on the substrate there is applied a coating comprising 37% crystalline polytetrafluoroethylene, 50% lead powder and 13% phenolic resin, there follows b) heat treatment of the coated substrate for pre-condensation of the phenolic resin at about 85°C. for 60 minutes, whereafter c) the coating is pressed with the adhesive layer at 90°C. and a pressure of from 20 to 40 MPa and then, for hardening the phenolic resin, d) there follows a pressureless heat treatment at 145°C. for 25 minutes and, e) the coating is post-compressed against the substrate at 90°C. and 20 to 40 MPa pressure.

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## SPECIFICATION

**Process for the production of a composite friction bearing material**

5 The present invention is concerned with a process for the production of composite friction bearing material from a preferably powdered or granular mixture of polytetrafluoroethylene, lead and synthetic resin, especially phenolic resin, which is applied to a pre-treated, metallic substrate with a porous adhesive layer and, by the application of alternating pressures and temperatures, is caused to adhere and is consolidated in such a manner that, in the final state, over the adhesive layer there is obtained a bearing material layer of at least 0.2 mm.

10 Composite friction bearings as machine elements for the transmission of power from moving to stationary machine parts have been known for many years. They consist of at least two work materials with different mechanical properties: a supporting body or a substrate which takes up the bearing material and mainly ensures the take up of power and a layer of bearing material which ensures the relative movement of the moving to the stationary bearing component without disturbance in all operational states. Depending upon the bearing load, given by the magnitude of the forces to be taken up, the rubbing speed and constructional characteristics, various metallic and non-metallic sliding materials have hitherto been used in composite friction bearings.

15 To the best known metallic sliding materials belong, for example, lead bronzes, tin, cadmium and the like, whereas as non-metallic sliding materials there are known graphite and, in particular, synthetic resins in the form of phenolic resins and polyfluoroolefins.

20 In order to be able to utilise the advantages of the most varied bearing materials without having to put up with their disadvantages, highly stressed friction bearings are generally of multi-layer construction and, for maintenance-free operating friction bearings, the participation of polytetrafluoroethylene has proved to be especially preferable. Such friction bearings and processes for the production thereof are known, for example, from Federal Republic of Germany Patent Specification No. 1,065,182, British Patent Specification No. 1,025,036 and U.S. Patent Specification No. 2,691,814. According to these, a metallic carrier body is appropriately pre-treated and a porous bronze powder layer is then sintered thereon. On to this sintered structure is applied crystalline polytetrafluoroethylene alone or in combination with metallic lead, this coating being pressed into the porous sintered bronze layer with the application of heat. In order, on the one hand, to bond the polytetrafluoroethylene particles with the sintered

structure and, on the other hand, to make the mechanical properties of the polytetrafluoroethylene itself more favourable, a heat treatment above the crystal melting point of 327°C., preferably at 350 to 400°C., is a process step regarded as being necessary.

70 These known friction bearings operate without maintenance but the production thereof is difficult and laborious. Besides the sintering on of the bronze powder, it is, from the energy point of view, especially disadvantageous that the complete friction bearing body must, for the recrystallisation of the polytetrafluoroethylene, be exposed to a temperature above 327°C. for a certain period of time and thereafter must be quenched in order to achieve the amorphous state.

75 Finally, it is disadvantageous that the thickness of the layer lying above the sinter bronze is generally less than 50 µm. and this thin layer, in practical use, as friction bearing material, is rapidly worn off so that the load lies at least partly on the sintered structure, which considerably increases the friction value. Furthermore, in the case of running layers of the stated thickness, it is practically impossible to carry out working by turning which, for some cases of use, is regarded as being disadvantageous.

80 German Democratic Republic Patent Specification No. 61,393 describes a process for producing bearing materials which overcomes the disadvantages of the above-described friction bearings. In this case, on to a metallic substrate, which has been pre-treated, there is applied a synthetic resin dissolving binding agent based on butyl acetate and there is then applied thereon a powdered or granular mixture of polytetrafluoroethylene, lead and phenolic resin in a weight ratio of 30:57:13, followed by consolidation thereof at alternating pressures and temperatures.

85 Although this process manages without a sintering apparatus and thus the high temperatures required for the sintering process are avoided and, as a result of a thicker bearing layer, an after-working by turning is also possible, nevertheless heating the bearing material to a temperature above 327°C. is necessary in order to convert the crystalline polytetrafluoroethylene present in the mixture into an amorphous state, as well as to obtain this state by means of quenching.

90 It is an object of the present invention to provide a technically simplified process for the production of a friction bearing material with especially good bearing properties for maintenance-free operation.

95 It is a further object of the present invention to provide a process for the production of a composite friction bearing material with a running layer made of polytetrafluoroethylene, lead and phenolic resin, which process can be carried out at lower temperatures, for example below 100°C.

Thus, according to the present invention, there is provided a process for the production of a composite friction bearing material from a preferably powdered or granular mixture of polytetrafluoroethylene, lead and synthetic resin which is applied to a pre-treated metallic substrate with a porous adhesive layer and with the use of alternating pressures and temperatures for the adhesion in such a manner that, in the final state, over the adhesive layer there is obtained a friction material coating of at least 0.2 mm. thickness, wherein a) on the adhesive layer connected to the substrate there is first carried out, by means of an appropriate device, a dry coating with a mixture of a sliding material comprising, by weight, 37% of crystalline polytetrafluoroethylene, 50% of lead powder and 13% of phenolic resin, there then follows b) a heat treatment of the coated substrate for pre-condensation of the phenolic resin at about 85°C. for 60 minutes, whereafter, c) the coating is pressed with the adhesive layer at a temperature of about 90°C. and a pressure of from 20 to 40 MPa and then, after hardening the phenolic resin, d) there follows a pressureless heat treatment at a temperature of about 145°C. for 25 minutes and finally e) the coating is post-compressed against the substrate at a temperature of 90°C. and a pressure of about 20 to 40 MPa.

For a good bonding of the metallic and non-metallic components of the sliding material mixture to one another and to the substrate, it is advantageous when the particle size of the polytetrafluoroethylene is less than 600  $\mu\text{m}$ ., that of the lead powder is less than 80  $\mu\text{m}$ . and that of the phenolic resin is less than 100  $\mu\text{m}$ .

The adhesion of the sliding material layer, as well as of the adhesive layer, to the substrate, which is preferably a steel sheet, can be improved by mechanically or chemically roughening the substrate on the side to be coated, preferably by grinding.

According to another embodiment of the present invention, instead of applying the sliding material mixture in powder form, it can be applied to the adhesive layer in the form of a paste. For this purpose, the phenolic resin is dissolved in an appropriate diluent, for example in spirit, mixed with the other components and sprinkled or raked on. The use of a diluent has the advantage of binding dust in the case of working up and of a fine dissolving of the phenolic resin. However, before further working up, it is necessary to evaporated the solvent from the coating material for a certain period of time at ambient or elevated temperature.

According to a preferred embodiment of the present invention, the pressing and post-compression of the friction bearing material takes place with a pressure action of 25 seconds.

By means of the present invention, the

known good running properties of maintenance-free friction bearings with polytetrafluoroethylene and metallic additives are fully maintained. However, by means of the production process according to the present invention, the previously employed heat post-treatment and quenching of the friction bearing body can be omitted. The present invention offers the surprising advantage that the omission of the heat treatment of the polytetrafluoroethylene above the crystallisation melting point for the conversion of the structure from the crystalline form into the amorphous form, hitherto usually regarded as being necessary, proves to be so positive that, in combination with the described process steps, in the case of the participation of phenolic resins, a higher running capacity is achieved and that the binding of the running layer on to the substrate is extraordinarily good in spite of the omission of a high temperature treatment. A so-called reversible reformation of the polytetrafluoroethylene admittedly leads to a mechanical consolidation thereof, which is required and is also used for friction bearing materials produced in other ways with large amounts of polytetrafluoroethylene, but, in the case of the process according to the present invention for the production of composite friction bearing materials, this can advantageously be omitted. Nevertheless, under maintenance-free conditions, there can, with limitation, be achieved a considerably greater life, the homogeneous composition of the running layer thereby acting in full thickness as a dry lubricant.

The higher functional value of the composite friction bearing material produced by the process according to the present invention also results from the fact that the low degree of thermal stressing during the production thereof completely excludes thermal damaging of the phenolic resin. A further advantage of the carrying out of the process according to the present invention is also the pressureless thermal hardening of the phenolic resin component of the friction bearing mixture, which is not usual for the working up of phenolic resins of the kind used, which, in combination with the other process steps used, provides especial advantages.

The process according to the present invention can be carried out in a large variety of ways.

The following Examples are given for the purpose of illustrating the present invention:

#### Example 1

A 1.5 mm. thick steel sheet is degreased by pickling, whereafter one surface thereof is roughened by grinding. A porous, metallic adhesive layer is applied to this pre-treated steel sheet surface in known manner, whereafter a dry, homogeneous sliding material mixture is applied thereto, this mixture com-

prising, by weight, 37% of crystalline polytetrafluoroethylene, 50% of lead powder and 13% of phenolic resin, the mixture having previously been intensively mixed. The polytetrafluoroethylene used has a particle size of less than 600  $\mu\text{m}$ ., the lead powder has a particle size of less than 80  $\mu\text{m}$ . and the phenolic resin has a particle size of less than 100  $\mu\text{m}$ . The coating is carried out to a thickness of about 2.5 mm. in a sprinkling or raking device.

The coated steel sheet is then subjected to a heat treatment in an oven at 85°C. for 60 minutes in order to achieve a precondensation of the phenolic resin. Subsequently, the sliding material mixture is compressed against the adhesive layer and the steel substrate at an apparatus temperature of about 90°C. and a pressure of from 20 to 40 MPa for 25 seconds. Instead of using a press for the consolidation, there can also be used a calendar with heated rollers, the roller diameter being 0.3 metres.

After the consolidation, there is achieved a hardening of the phenolic resin in the sliding material mixture by means of a heat treatment at 145°C. for 25 minutes without the application of pressure. Subsequently, the hardened running layer is post-consolidated at a temperature of 90°C. and at a pressure of from 20 to 40 MPa for 25 seconds. Hereafter, the surface of the applied polytetrafluoroethylene-lead-phenolic resin mixture can be ground to a uniform thickness so that the total thickness of the friction bearing is, for example, 2 mm.

The composite friction bearing material present in planar form can be used as a strip but can also be divided up into any desired shapes or can be rounded to give journal bearing bushings or can be punched out to give thrust washers.

#### Example 2.

A 0.5 mm. thick steel sheet is pre-treated as in Example 1 and provided with an adhesive layer. The phenolic resin of the friction bearing running layer is dissolved in an appropriate medium, for example in spirit. The two other components, polytetrafluoroethylene and lead, are added to this solution, with vigorous stirring, in the given percentage amounts, optionally with further solvent, so that a slurry-like, pasty mass is formed. This is applied to the adhesive layer in a thickness of about 1.5 mm. by means of a rake device. Before further working up, the solvent is first evaporated off for several hours, in dependence upon the thickness of the layer applied and upon the ambient temperature, for example for 5 to 20 hours at ambient temperature. There then follows the further process steps of precondensation, consolidation, hardening and post-consolidation as described in Example 1. A grinding working up is also carried out so that a composite friction bear-

ing can be produced with an overall thickness of, for example, 1 mm.

The composite friction bearing material according to the present invention is characterised by especially advantageous running properties in maintenance-free operation. Thus, in the case of running experiments with composite friction bearing materials according to the present invention and with friction bearings produced by previously known processes, substantially longer running times are achieved with the materials according to the present invention. In the case of a circumferential speed of 2.4 m/s of a pin against a thrust washer, as well as a specific surface loading of 0.5 MPa, up to a wear of 124  $\mu\text{m}$ . there could be measured, for example, 1500 to 2500 running hours, whereas, under the same conditions, in the case of the known bearings, only about 250 to 400 running hours were measured.

#### CLAIMS

1. Process for the production of a composite friction bearing material from a preferably powdered or granular mixture of polytetrafluoroethylene, lead and synthetic resin which is applied to a pre-treated metallic substrate with a porous adhesive layer and with the use of alternating pressures and temperatures for the adhesion in such a manner that, in the final state, over the adhesive layer there is obtained a friction material coating of at least 0.2 mm. thickness, wherein a) on the adhesive layer connected to the substrate there is first carried out, by means of an appropriate device, a dry coating with a mixture of a sliding material comprising, by weight, 37% of crystalline polytetrafluoroethylene, 50% of lead powder and 13% of phenolic resin, there then follows b) a heat treatment of the coated substrate for pre-condensation of the phenolic resin at about 85°C. for 60 minutes, whereafter c) the coating is pressed with the adhesive layer at a temperature of about 90°C. and a pressure of from 20 to 40 MPa and then, for hardening the phenolic resin, d) there follows a pressureless heat treatment at a temperature of about 145°C. for 25 minutes and, finally, e) the coating is post-compressed against the substrate at a temperature of 90°C. and a pressure of about 20 to 40 MPa.

2. Process according to claim 1, wherein, in the sliding material mixture, the particle size of the polytetrafluoroethylene is below 600  $\mu\text{m}$ ., that of the lead powder is below 80  $\mu\text{m}$ . and that of the phenolic resin is below 100  $\mu\text{m}$ .

3. Process according to claim 1 or 2, wherein the pressing according to step c) and the post-compression according to step e) take place with a chronological pressure action of about 25 seconds.

4. Process according to any of the preceding claims, wherein the substrate is a steel

sheet which has been mechanically or chemically roughened on the side to be coated.

5. Process according to claim 4, wherein the roughening is carried out by grinding.

- 5 6. Modification of the process according to any of the preceding claims, wherein, alternatively to the coating on of the sliding material according to step a), this is converted into a pasty form by dissolving the phenolic resin in an appropriate solvent and the paste is raked on to the adhesive layer and, prior to the subsequent pre-condensation, the solvent is evaporated off to dryness.

- 10 7. Process according to any of the preceding claims, wherein the surface of the friction bearing work material is subjected to a known cutting after-treatment.

- 15 8. Process according to claim 7, wherein the cutting after-treatment is carried out by milling.

20 9. Process according to claim 1 for the production of a composite friction bearing material, substantially as hereinbefore described and exemplified.

- 25 10. Composite friction bearing material, whenever produced by the process according to any of claims 1 to 9.